SPRAYING FOR THE SAN JOSE SCALE.

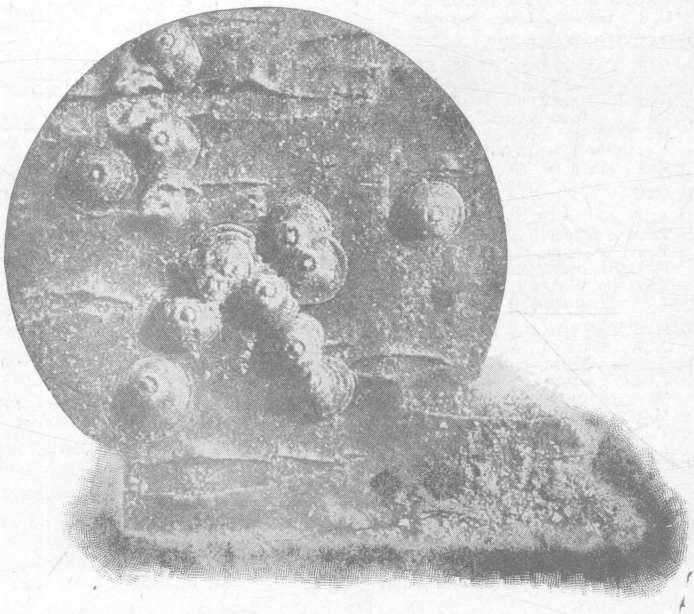
NOTES ON THE USE OF SULFUR SPRAYS;

OTHER COMPOUNDS; AND FALL *vs* SPRING APPLICATIONS.

OHIO
Agricultural Experiment Station.

WOOSTER, OHIO, U. S. A., JANUARY, 1906.

BULLETIN 169.



THE SAN JOSE SCALE—WINTER STAGE.
Enlarged 18 diameters.

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BULLETIN

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PREFACE.

Upon accepting the supervision of the entomological work of the Ohio Experiment Station, I found that investigation of remedies for San Jose scale was in progress. Prof. P. J. Parrott had issued Bulletin 144, reviewing some of his experiments, but part of the data collected by him was still unpublished. Mr. Houser, as the remaining representative of the department, was vigorously carrying forward the campaign initiated by Mr. Parrott, and had accumulated considerable information on his own account. I found that he had the work so well in hand that, while I have had the supervision of it since my coming, have given the deciding voice in all experimental plans outlined, and have conducted part of the field operations and examinations in person, yet his suggestions have, in the main, been so closely followed and so much of the field work has been performed by him, that I have requested him to write out the results and publish them under his own name. This bulletin, in combination with No. 144, brings our experimental knowledge of treatment for San Jose scale down to date.

H. A. GOSSARD.
Entomologist.

OUTLINE.

SPRAYING FOR THE SAN JOSE SCALE.

BY J. S. HOUSER.

INTRODUCTION.

The Station first began experimental work with the sulfur sprays in the fall of 1902, the test being conducted by Prof. P. J. Parrott, who was then Entomologist of the Station. The detailed account of the experiment will be found in Bulletin 144. Since the date of this experiment, extensive work has been done in three different sections of the state, namely: at Danbury, Ottawa County, Akron, Summit County and Mentor, Lake County. A number of the sulfur sprays, together with a few of the more widely advertised commercial remedies, have been tested; also late fall *vs.* spring applications have been given some attention. Approximately 7000 trees, including apple, pear, peach, plum and cherry, have been used in the process.

It is the purpose of this bulletin to set forth the work not reported and discussed in the previous publication.

FORMULÆ USED.

Since the advent of the sulfur sprays for orchard use, many different formulæ for their preparation have been suggested from time to time, the object being to obtain the most effective spray at a minimum cost, and to develop a wash which could be prepared without the use of external heat.

Boiling with fire or steam is the means usually employed to bring about the combination of the lime and sulfur necessary to make the wash effective; but this process is tedious and laborious, so it has been replaced with varying success by the addition of some other material to the formula to bring about the union. Either caustic soda or caustic potash is the additional ingredient ordinarily employed, and of the two, the soda is the more commonly used.

In all the work where external heat was necessary in the preparation of the wash it was supplied by live steam. This topic will be treated more fully upon a later page.

The following list includes the formulæ for the various washes that have been tested:

BOILED WASHES.

I. FALL AND SPRING APPLICATIONS.

(1)	Lime	16⅔	lbs.	Sulfur	16⅔	lbs.	Salt	16⅔	lbs.	Water 50 gals.
(2)	"	30	"	"	16	"	"	16	"	" 50 "
(3)	"	31	"	"	16	"	Copper sulfate	2⅓	"	" 50 "
(4)	"	16	"	"	16	"	Salt	16	"	" 50 "
(5)	"	15	"	"	15	"	"	15	"	" 50 "
(6)	"	15	"	"	15	"	.....			" 50 "
(7)	"	15	"	"	15	"	Glue	1	lb.	" 50 "
(8)	"	15	"	"	15	"	"	2	lbs.	" 50 "
(9)	"	16⅔	"	"	8⅓	"	Salt	16⅔	lbs.	" 50 "
(10)	"	31	"	"	8	"	"	8	"	" 50 "
(11)	"	15	"	"	7½	"	"	15	"	" 50 "
(12)	"	15	"	"	7½	"	.....			" 50 "
(13)	.....	.....		.....			"	15	"	" 50 "

II. SUMMER APPLICATIONS.

(1)	Lime	1	lbs.	Sulfur	1	lbs.	Water 50 gals.
(2)	"	2	"	"	2	"	" 50 "
(3)	"	5	"	"	5	"	" 50 "
(4)	"	10	"	"	10	"	" 50 "

SELF-BOILED WASHES.

I. SPRING APPLICATIONS.

(1) Lime 25 lbs. Sulfur 16 lbs. Caustic soda 6 lbs. Copper sulfate 3lbs. Water 50 gals.

(2)	Lime	25	lbs.	Sulfur	16	lbs	Caustic soda	6	lbs.	Water 50 gals.
(3)	"	25	"	"	16	"	" potash	12	"	" 50 "
(4)	"	25	"	"	16	"	Lye	6	lbs.	" 50 "
(5)	"	15	"	"	15	"	Caustic soda	12	lbs.	" 50 "
(6)	"	32	"	"	8	"	Lye	4	lbs.	" 50 "

OTHER COMPOUNDS.

(1) Consol.
(2) Kerosene-limoid.
(3) Soluble Petroleum or Scalecide.

It was impossible to use all of these formulæ in each of the different orchards, or to repeat the program in the same orchards each year during the period of experimentation, so the results will be dealt with as a general whole. Some of the formulæ have been tested extensively and some upon a more limited scale.

RESULTS.

In a general way it may be said of the boiled washes that, where the tests were made under fair conditions, the first six formulæ produced very satisfactory results, and further, that there were no perceptible differences in the results between any two of them. In the light of this fact several inferences may be drawn:

SALT, COPPER SULFATE OR A LARGE EXCESS OF LIME ARE UNNECESSARY INGREDIENTS TO THE FORMULÆ.

At the time the sulfur sprays first came into use, salt was invariably included in the formulæ, as it was believed to add to the adhesive qualities of the wash, thus increasing its insecticidal value. Later the value of the salt was questioned, so in order to decide this point considerable attention has been given it. All told, several hundred trees were sprayed under varying conditions with mixtures in which the salt was omitted, and the results compared with those from trees sprayed under parallel conditions with a similar mixture to which salt had been added. In no case was there any perceptible difference in the length of time the two washes remained on the trees, nor in their effect upon the scale. Other experimenters report similar conclusions.

As a further test to determine the insecticidal value of salt, a number of pear trees were sprayed in November, 1904, with a solution in which 15 pounds of salt were dissolved in 50 gallons of hot water. The condition of these trees throughout the following season was identical with that of the unsprayed checks, thus indicating that neither harm nor good had come from the treatment. Salt therefore, seems neither to add anything to the persistency of the wash nor to contribute to its killing qualities.

Copper sulfate, when added to the mixture, was of no perceptible value, either from an insecticidal or a fungicidal standpoint.

Plots treated with sprays carrying a large excess of lime gave no better results than those sprayed with washes in which an equal amount of lime and sulfur had been used, provided the amount of sulfur reached the standard, 15 pounds to 50 gallons of water. Dr. E. P. Felt, State Entomologist of New York, states in a paper read before the 17th Annual Meeting of the Association of Economic Entomologists in December, 1904, that after consultation and comparison of data with Prof. P. J. Parrott, of the Agricultural Experiment Station at Geneva, N. Y., it was decided that a little more lime than sulfur was an advantage, after which both agreed to recommend 20 lbs. lime, 15 lbs. sulfur and 50 gals. water, the use of salt being optional.

We believe that it is well to hold the lime down to the minimum amount consistent with a perfect chemical combination of the lime and sulfur, as a large excess only thickens the mixture and causes clogging of the nozzles. In our experience 15 pounds to 50 gallons of water has been quite satisfactory, while 30 pounds made the wash too thick. Possibly the proportions recommended by Messrs. Felt and Parrott are better than either of these.

THE GLUE WASH.

This wash was applied early in December, 1903, to a mixed class of 95 trees, at Akron. Only a part of the lot could be counted in the test, as some were sprayed under adverse weather conditions. This unfairly sprayed lot will be commented on later.

The glue was added to the formula with the hope of increasing the sticking qualities of the wash. Examinations made during the season following indicated that it was valueless for this purpose, and the insecticidal properties of the wash were neither increased nor decreased in any other way because of its addition.

THE WEAKER WASHES.

The sulfur is the most expensive ingredient of the so-called sulfur sprays. After it had been demonstrated that, 15 pounds of sulfur to 50 gallons of the mixture, was effectual, the query arose as to whether this proportion could be safely reduced, thus lessening the cost of the spray. Where this was done, as in Formulæ 9, 10, 11 and 12, the results were less satisfactory. Although a considerable percentage of the scale was killed by such applications, enough remained alive to thoroughly restock the trees, and at the close of the season their condition would vary but little from what it had been before the treatment was applied. Of course some good was accomplished by preventing the scale from increasing the degree of infestation beyond the original status, but such results are hardly worth the expense and labor spent in obtaining them. To save the money value of the few additional pounds of sulfur that are required to bring the formula up to the right standard of effectiveness is very poor economy indeed.

BOILED WASHES. SUMMER APPLICATIONS.

These applications were made upon peaches in the Danbury region at the request of the owners of the orchard, June 25 to 30, 1903. Very little need be said about them, as like all summer applications against this insect, they were more orless unsatisfactory. Formulæ 1 and 2 killed some of the crawling larvæ and did not

injure the foliage. Formulæ 3 and 4 killed practically all of the larvæ and destroyed some of the newly set scales, but at the same time severely injured the trees. Most of the foliage dropped, together with the light crop of fruit, and a year from the time of the application, a number of the trees were dead.

THE SELF-BOILED WASHES.

The washes to which ordinary lye, caustic soda and the bulk caustic potash were added to the formula to unite the lime and sulfur, as a substitute for the ordinary boiling process, have been only moderately successful. On some occasions favorable results were obtained, while on others almost total failures were experienced. The caustic soda was the more extensively used, and results from this wash were extremely variable. It seems to make all the difference between success and failure whether all the ingredients of the formula are of the best quality, and whether every care is exercised in the mixing process to utilize all the heat possible that is generated by the slaking of the lime and the action of the soda or potash. Because of this tendency to give variable results, the unboiled washes are hardly as safe as the boiled for general orchard work.

The caustic soda formula was originated in the New York (Geneva) Experiment Station. In Bulletin 247 of that Station the results are reported good but not entirely satisfactory. However, later publications, (Bulletins 254 and 262), report the value of this spray as equal to that of the boiled sulfur sprays. The formula there used most extensively is as follows:

Lime 30 lbs. Sulfur 15 lbs. Caustic soda 4 to 6 lbs. Water 50 gals.

It will be noticed that a greater amount of lime was used in this work than has been customarily employed in Ohio. The reports coming from several of the other experiment stations do not wholly agree on the value of the caustic soda washes. The Connecticut Station, in Bulletin 146, and the Maryland Station, in Bulletin 99, report good results, while the Delaware Station, in Bulletin 64, reports them to be only partially satisfactory; and the New Jersey Station, in Bulletin 178, says the wash in their experiments was of very little value.

OTHER COMPOUNDS.

The other compounds that have received our attention have been tested upon small areas and for one year only. The tests were made under favorable conditions upon scale infested pears, at Mentor, in April, 1905, each plot including not more than a dozen trees and not fewer than five.

Consol.—This material is manufactured by the American Horticultural Distributing Co., of Martinsburg, W. Va., and is said by them to be a concentrated lime-sulfur wash with other ingredients, each valuable in itself. Two samples have been sent to us for trial. A two gallon consignment came first and was soon followed by another of one gallon, with the statement that the latter had been prepared by an improved process. Both lots, after being thoroughly stirred, were diluted with water in the proportion of 1 to 40.

During the season following, no difference could be noticed between the condition of the trees sprayed with either of the samples and that of the unsprayed check trees. In other words, Consol was of no perceptible value.

Kerosene-limoid.—This compound is prepared by mixing in certain proportions, kerosene, limoid and water. The limoid is a dry-slaked, magnesian stone-lime, and is manufactured by the Chas. Warner Co., of Philadelphia, Pa. and Wilmington, Del. In our work, two gallons of kerosene and nine pounds of limoid were well stirred together, after which 5 gallons of water was added, and the whole violently churned for two minutes with a perforated dasher. At the end of this time, together with 7½ gallons of water, it was thrown into the spray barrel and agitated for an additional three minutes by the use of the spray pump, after which it was taken to the orchard and applied without unnecessary delay. Two very marked and disagreeable tendencies of the wash were exhibited in the spraying process. First, it was noticed that the nozzles clogged very badly; and second, when the wash was sprayed on the trees, it did not settle and spread evenly, but collected in globules, thus necessitating the use of excessive amounts in order to make the treatments thorough.

The results were not wholly satisfactory, as a considerable quantity of new scale set during this past season. This amount was apparently about equal to that which set upon trees treated with the half strength sulfur sprays. Prof. C. P. Close, of the Delaware Experiment Station (Bul. 68) has had better success with this wash. When used upon peaches in that state, in April, it was apparently as efficient as the lime-sulfur-salt mixture.

However, in Prof. Close's work, a slightly stronger mixture was used, and this may account for the variation in results. The two formulæ are as follows:

(Delaware)	Kerosene 5 gals.	Limoid 20 lbs.	Water 19¼ gals.
(Ohio)	" 4 "	" 18 "	" 25 "

The Maryland Experiment Station (Bul. 107) reports very poor returns from the use of this wash, prepared after the Delaware formula, as cited above.

Scalecide.—This material is a soluble petroleum, manufactured by the B. G. Pratt Co., No. 11 Broadway, New York City, by whom it is retailed at $1.00 per gallon in gallon lots, with a decreasing rate in proportion to the size of the consignment sold, until a figure of 50 cents per gallon is offered on barrel (50 gal.) lots. Differing from most oils, it mixes readily with water, so all that is necessary in its preparation is to place it in the spray tank with the desired quantity of water and stir vigorously for a short time. A white, milky fluid results, from which the oil does not readily separate. In this test, 1 gallon of the oil was diluted with 20 gallons of water.

The material is easy and pleasant to apply, as it works smoothly in both pump and nozzles; spreads well upon the sprayed surface; and lastly, is not irritating to the skin. The results following its use have been more satisfactory than those given by any of the patent mixtures. In fact, the condition of the trees sprayed with one application was only slightly inferior to that of the trees sprayed with the normal sulfur washes. Although the test was a small one and the trial extended over one season only, Scalecide gives indications of becoming a valuable addition to the list of destroyers of the San Jose scale.

In Bulletin 107, of the Maryland Experiment Station, however, it is reported that Scalecide applied in the spring gave very poor results. Some of the scale was destroyed, but enough remained to thoroughly restock the trees during the breeding season immediately following; and, at the close of that period, the trees were in worse condition than before treatment.

FALL AND SPRING APPLICATIONS.

In the following discussion, in which the merits of the sulfur sprays, when applied at different seasons, are considered, the comparisons will be based upon results following the use of the boiled washes in which at least 15 pounds of sulfur to 50 gallons of water were used. The self-boiled and the weaker washes were tested mainly in the spring work.

The sulfur sprays cannot be applied while trees are in foliage. First, as has been shown previously, because of the disastrous

results that follow when this is done before the leaves have ripened; and second, because of the difficulty in making a thorough treatment at such a time. Neither can they be applied during the winter, because of unfavorable temperatures. With these seasons eliminated, there remain only late fall, after the leaves have dropped, and early spring, before leaves or blossoms have made their appearance, in which the work may be done.

Upon the introduction of the sulfur sprays, the spring period only was thought suitable for their use; later it developed that the late fall period also might possibly be used to advantage, However, as some doubt existed as to the probable effect of the spray when applied at this time, it was determined to extend our experimental work over both seasons.

The length of these periods, and especially that of the fall, depends largely upon the kind of tree to be sprayed. For instance, peaches are well adapted to fall spraying, because they shed their foliage early, while apples are very difficult to treat, inasmuch as the leaves are retained until well into the beginning of winter. In the spring, the time of blossoming and bursting of the leaf buds does not vary so greatly and hence, the differences are not so obvious.

The greater part of our experimental spraying has been done during the spring period, some 450 trees only having received the the fall treatment. The results from the fall work, as a whole, have been hardly as good as those from the spring.

At Akron, trees treated in December, 1903, with formulæ containing the standard amount of sulfur, gave very good results when the application was made while the thermometer stood above the freezing point. The leaves clung very persistently to the apple trees that season, hence it was impossible to begin the work sooner than Dec. 2nd. By that time cold weather had begun and some of the spraying was done under very adverse conditions, and all of it at an increased amount of labor and waste of time. All parts of the pump, the steam pipes and water leads, had to be drained each evening to prevent freezing during the night; frequently we were detained in the morning by the presence of heavy frost upon the trees, which made it impossible to spray until the sun had melted the frost and dried the limbs; and lastly, low temperatures during the day made the work disagreeable and tedious. Some of the spraying was done with the thermometer considerably below freezing and with some three inches of snow upon the ground. The spray, passing through the snow, imbedded hose, was considerably cooled by the time it reached the nozzle, and hence was liable to cause clogging.

When the nozzles once became clogged, it was found to be almost impossible to start them again without emptying the cooled mixture from the hose, which one can readily see was a very wasteful procedure. The spray froze a moment after settling upon the tree, and this fact undoubtedly was in part accountable for the poor results that followed. The wash applied under these conditions worked very unevenly, some portions of the tree being almost cleared of the scale, while others were scarcely affected at all.

For further verification of the work reported in Bulletin 144, fall applications were again tested at Mentor, in November, 1904. Large apples and pears were used in this test, all being badly incrusted with the scale, while some were infested to such an extent as to be in a dying condition. It was estimated, at the beginning of the season following, that about 10 or 15 percent of the scale upon the pears had survived the treatment, and a greater percent, probably 20 to 25, was still alive upon the apples. At the close of the breeding season of 1905, the trees are again badly infested, but in no case is the condition of the trees treated with a sulfur spray carrying the normal amount of sulfur (15 to 20 lbs. to 50 gals. of water) to be compared in degree of infestation, with the unsprayed check trees. These results are hardly as satisfactory as usually follow the use of the full-strength sulfur sprays.

The partial failure may be ascribed to two causes. First: to the thorough incrustation of the scale upon the trees through which the wash might not have been able to penetrate in all instances to the insects beneath; and second, to the fact that it was found to be exceedingly difficult to make the spraying thorough upon the apple trees because of their height and because of adverse winds at the time of application.

The spring work has been conducted upon a much larger scale than the fall work. Very large tests were conducted at Danbury, in 1903 and 1904, and smaller ones at Akron and Mentor, in the spring of 1905. The results at Akron and Danbury were uniformly good, it being estimated that between 95 and 99 percent of the scale was killed by a single treatment. At Mentor, some of the results were not so good. However, it seems quite probable that this partial failure was due to the same unfavorable circumstances that figured in the test the fall previous, rather than to any inferior work on the part of the sprays. Where the applications were made to smaller trees, not so roughly barked nor as thickly encrusted as the larger ones, and growing apart from them, thus lessening the possibility of re-infestation, the returns were all that could be desired.

For several reasons the spring period has been the more satisfactory of the two seasons for the use of the sulfur sprays. Ordinarily the weather at this season is more favorable for the work than during the fall. The days are longer and more can be accomplished; the season itself is of longer duration; and lastly, our results have inclined slightly in favor of the spring work. The New York (Geneva) Station and others, report no variation in the results following the use of the sprays applied during the two seasons. In the light of our experience, it would seem advisable in general orchard work to spray in the fall only in those instances where it is foreseen to be impossible to do the work in the spring, and, in cases of extreme infestation, to make a fall spraying with the intention of following it with another in the spring. Otherwise, and if one application only is to be made, defer the work until the spring period.

HOW OFTEN MUST WE SPRAY?

The question is frequently put: "How often must we spray our orchards after they have become infested with the scale, in order to keep it under control ?"

Several hundred peach trees were sprayed at Danbury, Ohio, in the spring of 1903, mainly with the full-strength sulfur sprays. During the season following, as the scale appeared to have become pretty well cleared from the trees, it was thought that if a second application were given the next spring (1904), it might be possible to pass the following spring (1905) without spraying. Accordingly, the second spraying was made in April, 1904, using formula No. 1.

An examination made early in the spring (1905) revealed the fact that a dangerous amount of live scale yet remained on the trees; so the owners of the orchard, at variance to the original plan, were advised to spray the main part again. However, a small section was reserved and left unsprayed. In this area, the scale, having been left unmolested for the two seasons, has multiplied quite rapidly, and has again gained a strong foothold. Besides spreading upon the branches, both the fruit and leaves this past season were badly spotted.

From this experiment it would seem that the answer to the question is that after an orchard once becomes well infested, annual spraying will be a necessity.

INCIDENTAL RESULTS ON FUNGOUS DISEASES.

The sulfur sprays, in addition to their value as insecticides, are also useful as fungicides. This fact has been most noticeable in our work in the Danbury region, with regard to controlling the peach leaf curl. Varieties of peaches susceptible to the disease

were not in the least affected by it where thoroughly sprayed, and bore a heavy crop of fruit and foliage, while their unsprayed neighbors not only lost all their fruit and foliage, but in addition were permanently injured. Some idea of the conditions may be had by referring to Plates I, II and III.

The half-strength boiled wash, Formula 9, being the only one tried, contrary to its workings as an insecticide, proved a valuable fungicide, as a single spraying made in April completely controlled the leaf curl.

Since those varieties of peaches included in the test, which were susceptible to the attack of the curl, have been given spring applications of the boiled mixtures only, it cannot be said at this time just what effect the self-boiled mixtures, or fall sprays of either would have upon this disease. Neither is it possible to say from personal experience to what extent any of the other fungous diseases may be controlled by the use of sulfur sprays, as present data are scarcely adequate to warrant a statement.

PREPARATION OF SPRAYS.

COOKED.

Where external heat was necessary in the preparation of the washes that have been mentioned in this bulletin, it was furnished through the agency of live steam. The steam was generated by upright boilers, varying from 4 to 8 horse power. In mixing the ingredients of the formula, the usual practice has been to start the full amount of lime to slaking in the cooking vat with from 4 to 8 gallons of hot water, then at the same time, if apparently necessary, to turn on the steam for a moment to accelerate the slaking. After the slaking of the lime was well under way, the sulfur was thrown in, as it was found to mix better and required less stirring if introduced at this time. Both of these facts were undoubtedly due to the intense heat and violent boiling which always accompany the rapid slaking of lime. The sulfur was used either in the dry state or in the form of a paste. If used dry, it was found necessary to add water from time to time, lest the mixture become too dry and the remaining unslaked lime burn. A stirring stick was always kept in the mixing barrel and used as occasion demanded.

After the action due to the slaking of the lime had ceased, the mixture was thoroughly stirred and diluted to a quantity varying from 16 to 20 gallons, and boiled from forty-five minutes to an hour and a half, after which it was transferred to the diluting tank and diluted to make 50 gallons in all.

If salt or copper sulfate was used in the formula, the salt was added at any time during the boiling process. The copper sulfate, after having been previously dissolved, was poured into the wash just before it was placed in the spray tank. In preparing the glue wash the usual procedure was followed in mixing the lime and sulfur, the glue being added at the beginning of the boiling process.

SELF-COOKED.

In preparing the self-cooked washes, the lime and sulfur were used in the same manner as has been indicated in the preparation of the cooked sprays. After the action due to the slaking of the lime had ceasesd, the caustic material was added. With the caustic soda and lye washes, the soda or lye, as the case might be, was used dry, but with the bulk caustic potash spray, the potash was first dissolved in hot water.

After the action resulting from the presence of the caustics had stopped, the mixture was diluted to the proper consistency, with either hot or cold water, and the application made as soon as possible.

APPLICATION OF SPRAYS.

Where conditions have permitted, the spraying has been done with the wind. That is, one side of the trees was sprayed with the wind in one quarter, and the other side treated after it had shifted to the opposite direction. This has been found to be the most satisfactory way of doing the work. The mixture can be applied more evenly and thoroughly, with less waste and with a greater degree of comfort to the operators. It has been found to be a very good practice to make the first spraying as thorough as possible; then wait until the mixture dries and pass over the same ground again, retouching those parts of the trees that have been missed.

PUMPS.

Any pump with the working parts of brass, and furnishing a constant high pressure, is suitable. In this work either a Goulds Sentinel, or Goulds Sentinel Jr., manufactured by the Goulds Mfg. Co., Seneca Falls, N. Y., was used. A presssure gage upon the pump materially assists the operator in keeping an even pressure.

NOZZLES.

Nozzles of simple construction are the most desirable. Those possessing fine apertures produce a very fine, mist-like spray and are consequently best for low trees; while for higher trees, and where the spray must be thrown in the air to reach the tops, a coarser nozzle

serves the purpose better. In the majority of our spraying operations a cluster of six Spramotor nozzles has been employed and has given very good satisfaction. These nozzles are made by the Spramotor Co., of London, Ont. and Buffalo, N. Y.

AGITATORS.

Some arrangement should be provided for keeping the mixture well stirred during the process of spraying. If this be neglected, the heavier parts of the wash will settle, and the denser portion will be sprayed out first, leaving a weaker mixture for those trees treated with the last of the lot. It is easy to tell if the mixture is not properly agitated, as the trees sprayed first have a much whiter appearance than those sprayed last.

SOME COOKING OUTFITS.

The mixtures may be boiled either over a fire or by the use of steam. The first method is advisable only in those instances where the area to be sprayed is not sufficiently large to make worth while the purchasing of a steam outfit.

BOILING WITH FIRE.

Plate 5, Fig. 2 represents a typical outfit for preparing the mixture in this manner. With the two kettles, from 200 to 300 gallons of the mixture may be prepared in one day. This method has two very serious disadvantages: First, the fire is liable to vary, resulting in the cooling down or boiling over of the mixture; and second, unless carefully stirred, the lime and sulfur cake on the sides of the kettle.

Instead of kettles, iron feed cookers are sometimes employed and are said to give very good satisfaction.

BOILING WITH STEAM.

Boiling the wash with live steam is by far the more satisfactory of the two ways of cooking it. Greater quantities, of a more even wash, can be prepared in less time and with a greater degree of comfort to the man in charge, by this method. The capacity of the cooking plants depends upon their size and the degree of convenience with which they are arranged. Plate 4 represents an arrangement which has been found to be very satisfactory for small plants with a capacity of from 500 to 750 gallons per day, as well as for larger plants producing greater quantities of the wash. Types of the smallest and the largest cooking outfits are shown in Plate 6, Figs. 1 and 2. It is always better to arrange the outfit under shelter.

GENERAL REMARKS.

In all of the work it has invariably been found that the time consumed in carefully straining the wash was well spent. Two strainings are better than one. The first, to remove the larger particles, may be made as the mixture passes from the boiling to the diluting vat. A screen, composed of meshes about the size of those in ordinary window screening, serves the purpose very well.

The second straining may be made through a much finer meshed screen as the mixture passes from the distributing tank to the diluting tank. The strainers, together with the working parts of the pump and nozzles should be made of brass. While brass is less subject to corrosion by the wash than copper, it is more so than iron, but brass will not rust. Apparatus, subject to corrosion, should be carefully washed with clear water after each day's operations.

The sulfur sprays should be applied as quickly as possible after having been placed in the distributing tank. This is especially desirable in the case of the boiled mixtures, as it has been noticed that if the wash becomes considerably cooled, it is much more difficult to force through the nozzles.

A great difference is noticed in the degree of susceptibility to attack of the various kinds of orchard trees. Those possessing a tender bark are more liable to attack than those possessing tough bark. Some varieties of cherries are nearly immune.

The scale is more easily controlled on smooth barked trees than upon rough barked ones, by reason of the fact that the latter class affords so many protecting crevices in the bark, where the scale can set and into which the spray will not penetrate. These facts should be taken into consideration by persons who contemplate planting orchards in districts where the scale is known to be present.

Another feature which has been found to figure prominently in controlling the scale, is the size of the trees to be sprayed. It is almost impossible to spray large apple trees properly, unless some special arrangement in the way of an elevated, movable platform be used. The more simple solution of the problem is to top-prune the trees where it is considered to be at all practicable.

RECOMMENDATIONS.

A mixture prepared by boiling together, for at least forty-five minutes, 15 to 20 pounds lime and 15 pounds sulfur in enough water to form a thin liquid, and afterwards diluted to make 50 gallons, has been found in these experiments the most effective and practicable remedy for destroying the San Jose scale.

Ordinarily it is best to make the application in the spring, but if it is foreseen to be impossible to do the work at that time, a fall spraying should be made. In cases of extreme infestation it may be advisable to make both a fall and a spring spraying.

Care in the preparation of the wash and thoroughness in applying it are absolutely essential to success.

After the scale has become well established in an orchard, annual spraying seems necessary to hold it in check.

Boiling with steam is the most satisfactory way of preparing the wash.

ACKNOWLEDGMENTS.

In addition to the credit due Prof. H. A. Gossard for the work done by him as outlined in the preface, the writer wishes to express his appreciation for many suggestions given during the preparation of this manuscript.

Credit is also due Prof. P. J. Parrott for having personally conducted the first year's spraying operations at Danbury, and also for suggestions received from him for the continuance of the work, after he had assumed the duties of Entomologist of the New York Agricultural Experiment Station.

To the following persons who either owned, or had under direct supervision, the orchards in which the work was done and who aided in every possible way in the execution of the writer's plans, he is very grateful:

Mr. W. C. Yule and Miss Nellie Duroy, Danbury, O; Messrs. O. W. Hale and L. C. Cranz, Akron, O. and Mr. Chas. R. Neillie and H. B. Van Cleve, Mentor, O.

The prints for the illustrations were prepared by Mr. C. R. Hessler of this Station.

EXPLANATION OF PLATE I.

FIG. 1. A twig from an Elberta peach tree sprayed with a sulfur spray. Healthy.

FIG. 2. A twig from an Elberta peach tree left unsprayed. Attacked by peach leaf curl. Within a short time both leaves and blossoms fall.

PTATE I.

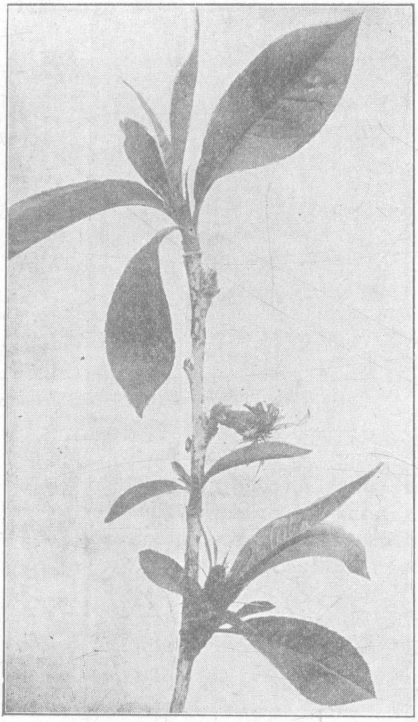


FIGURE 1.

FIGURE 2.

EXPLANATION OF PLATE II.

Elberta peach trees growing under parallel conditions, one sprayed, and the other unsprayed. Both photographs taken Sept. 29, 1903.

The sprayed tree, Fig. 1, bore 1½ bushels of marketable peaches and made a strong vigorous growth during the season, preparatory to producing a good crop the next year.

The unsprayed tree, Fig. 2, lost its entire crop of blossoms, all its first crop of foliage (that shown in the illustration being a new crop), and was permanently injured by the attack of peach leaf curl.

PLATE II.

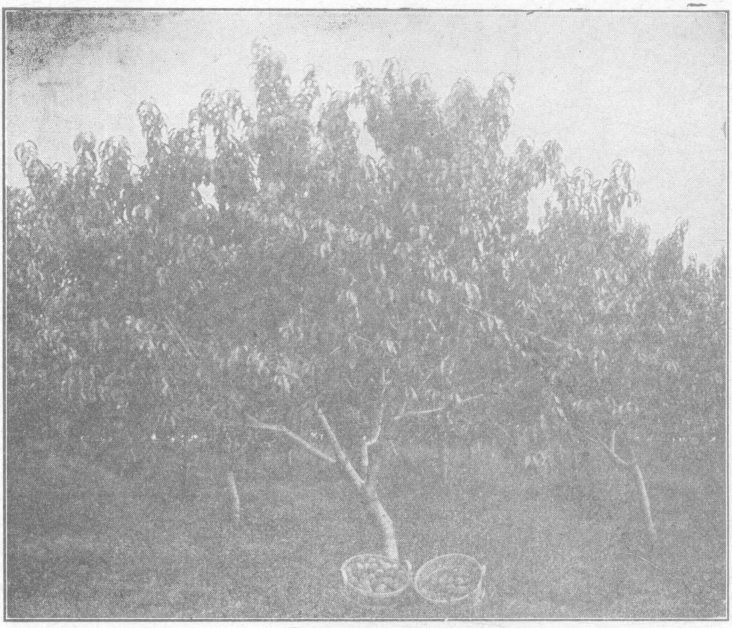


FIGURE 1.

FIGURE 2.

EXPLANATION OF PLATE III.

Two Elberta peach trees from the sprayed and unsprayed plots of 1903. Photographs taken Apr. 22, 1904 after the severe winter of 1903-4.

The sprayed tree, Fig. 1, passed the winter in excellent condition.

The unsprayed tree, Fig. 2, because of its weakened condition, fared badly. The illustration shows its appearance after the worthless wood was pruned away.

FIGURE 1.

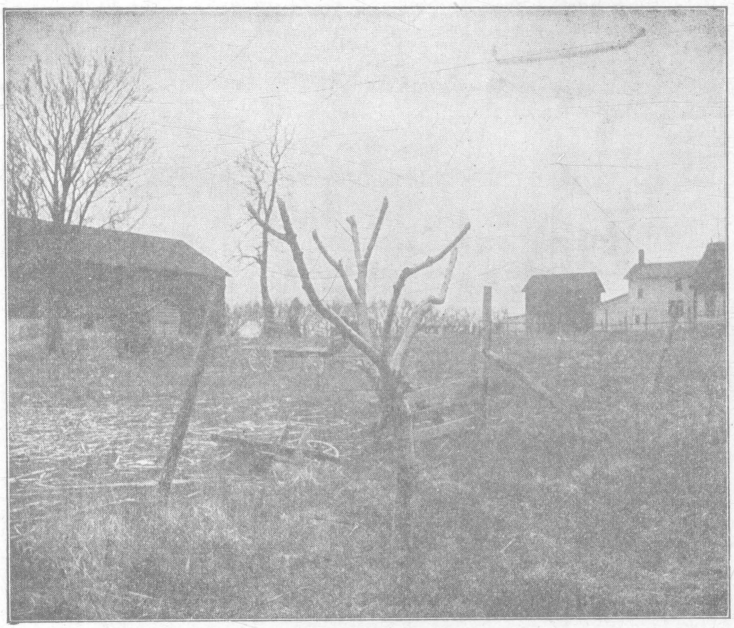


FIGURE 2.

EXPLANATION OF PLATE IV.

A convenient plan for the arrangement of the apparatus in a steam boiling plant.

A, boiling vat; *B*, water heating vat; *C*, diluting vat; *D*, boiler; *E*, water supply.

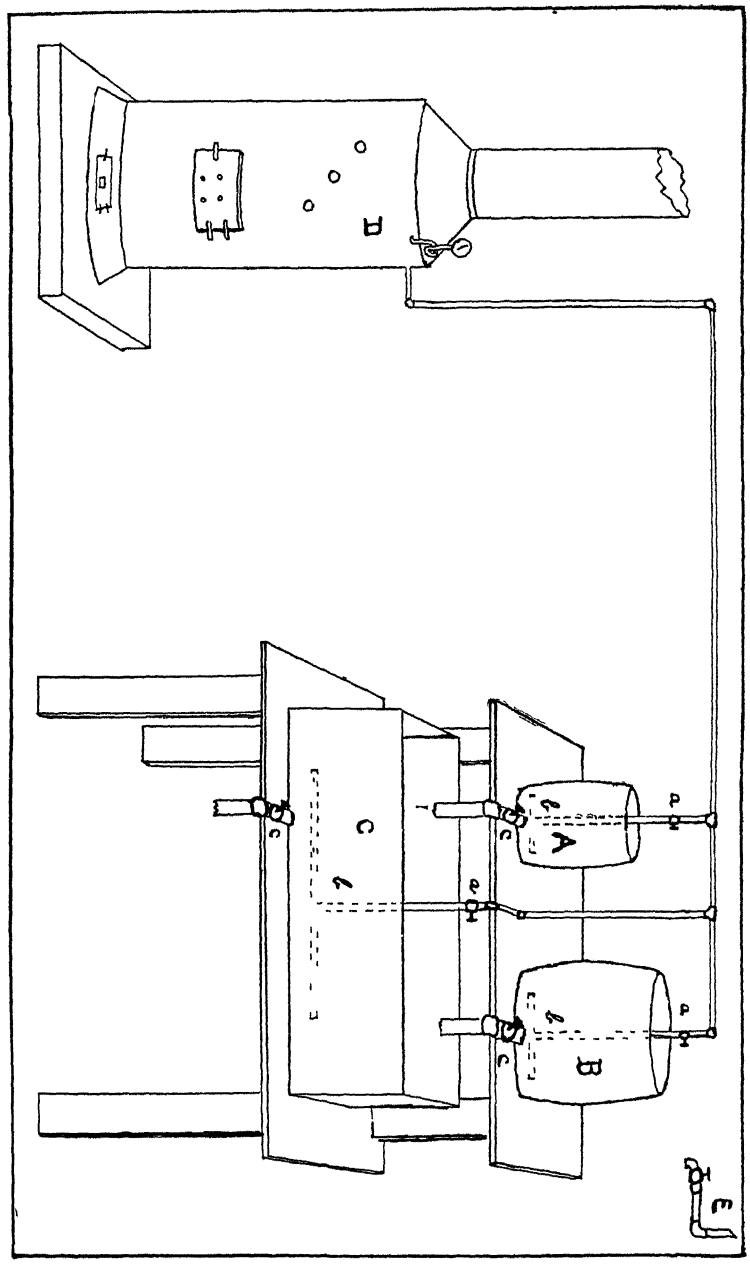
a, valves in steam pipe for controlling inflow of steam.

b, terminal cross pipes for distributing steam in vats.

c, outflows from vats.

NOTE.—The terminal cross pipes are plugged at the ends. To provide an outlet for the steam, a row of small holes were drilled in the front side of one of the arms, and in the back side of the other arm. The steam, rushing out in opposite directions, gives the mixture in the vat a twirling motion, which aids materially in keeping it well stirred during the boiling process.

PLATE IV.



EXPLANATION OF PLATE V.

FIG. 1. A very good apparatus for applying the mixture.

FIG. 2. Preparing the wash over an open fire.

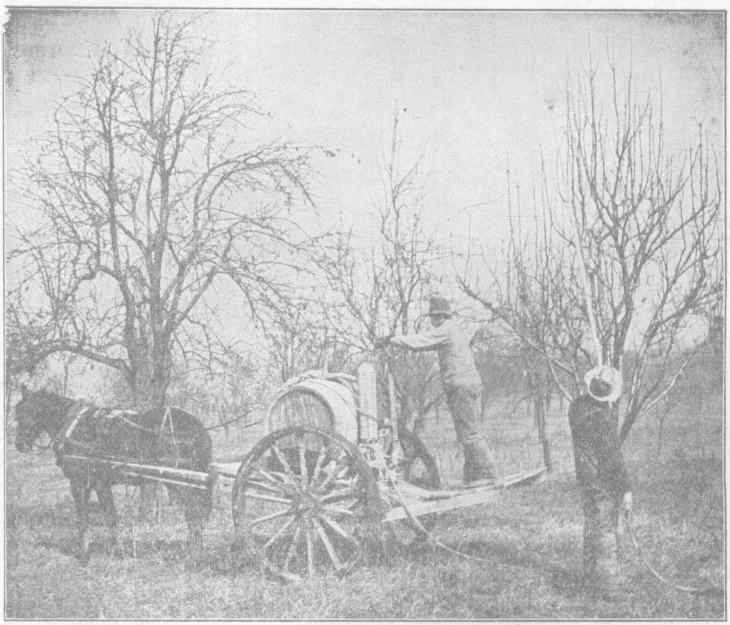


FIGURE 1.

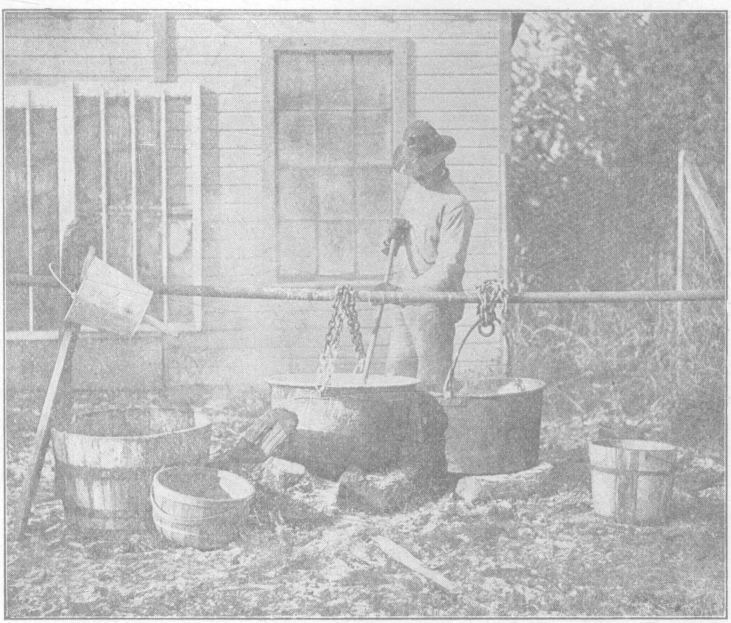


FIGURE 2

PLATE VI.

FIG. 1 Preparing the wash with a small steam outfit.

FIG. 2. A steam outfit capable of supplying the mixture for a large acreage.—*Photo. by Parrott.*

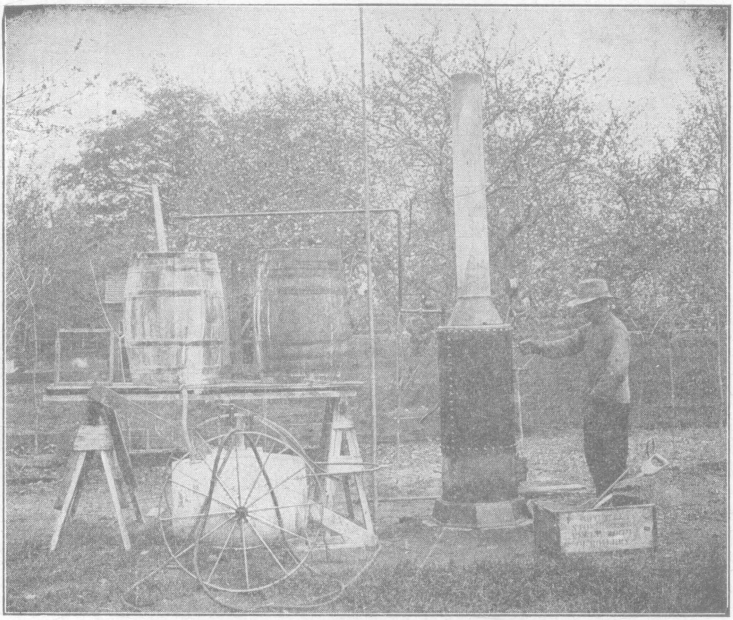


FIGURE 1.

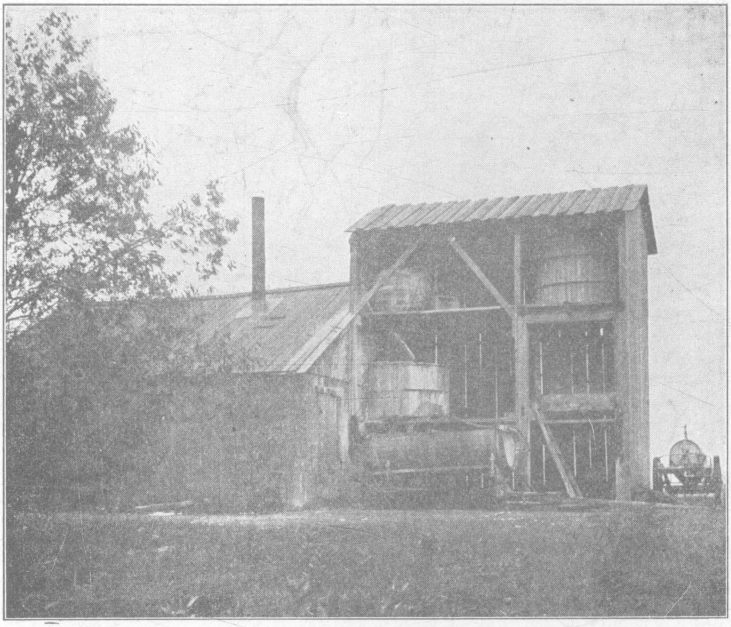


FIGURE 2.

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